TIMEOUT POSTPONEMENT WITHOUT INCREASED REINFORCEMENT FREQUENCY

CYNTHIA J. PIETRAS AND TIMOTHY D. HACKENBERG

UNIVERSITY OF FLORIDA

Three experiments were conducted to examine pigeons' postponement of signaled extinction periods (timeouts) from a schedule of food reinforcement when such responding neither decreased overall timeout frequency nor increased the overall frequency of food reinforcement. A discrete-trial procedure was used in which a response during the first 5 s of a trial postponed an otherwise immediate 60-s timeout to a later part of that same trial but had no effect on whether the timeout occurred. During time-in periods, responses on a second key produced food according to a random-interval 20-s schedule. In Experiment 1, the response–timeout interval was 45 s under postponement conditions and 0 s under extinction conditions (responses were ineffective in postponing timeouts). The percentage of trials with a response was consistently high when the timeout-postponement contingency was in effect and decreased to low levels when it was discontinued under extinction conditions. In Experiment 2, the response–timeout interval was also 45 s but postponement responses increased the duration of the timeout, which varied from 60 s to 105 s across conditions. Postponement responding was maintained, generally at high levels, at all timeout durations, despite sometimes large decreases in the overall frequency of food reinforcement. In Experiment 3, timeout duration was held constant at 60 s while the response–timeout interval was varied systematically across conditions from 0 s to 45 s. Postponement responding was maintained under all conditions in which the response–timeout interval exceeded 0 s (the timeout interval in the absence of a response). In some conditions of Experiment 3, which were designed to control for the immediacy of food reinforcement and food-correlated (time-in) stimuli, responding postponed timeout but the timeout was delayed whether a response occurred or not. Responding was maintained for 2 of 3 subjects, suggesting that behavior was negatively reinforced by timeout postponement rather than positively reinforced by the more immediate presentation of food or food-correlated (time-in) stimuli.

Key words: timeout postponement, timeout duration, timeout delay, negative reinforcement, random-interval schedules, key peck, pigeons

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Timeout from reinforcement is one of the most commonly used procedures in educational and therapeutic settings (see Brantner & Doherty, 1983, for a review). Like many behavioral procedures used in applied contexts, timeout from reinforcement has origins in basic laboratory research. Procedurally, timeout from reinforcement can be defined as a signaled period of extinction (Azrin & Holz,

1966). As such, timeouts are normally conceptualized as aversive events. This is clearly the function ascribed to timeouts in applied settings, where their response-contingent application is typically used to suppress unwanted behavior. Despite the widespread and generally efficacious use of timeouts in applied settings, surprisingly little is known about the exact circumstances under which timeouts from reinforcement serve an aversive function. Even under carefully controlled laboratory conditions, the evidence regarding the aversive functions of timeout from reinforcement is mixed and difficult to interpret.

One way to determine whether an event is aversive is to examine whether its termination or postponement will support responding. Indeed, some of the clearest evidence favoring a view of timeouts as aversive emerges from studies of timeout avoidance, in which responding is maintained by the postponement or cancellation of timeout from a schedule of positive reinforcement (D'Andrea, 1971; Ferster, 1958; Galbicka & Branch, 1983; Hackenberg, 1992; Morse & Herrnstein, 1956;

Thomas, 1964, 1965a, 1965b; van Haaren & Zarcone, 1994; Zimmerman, 1963).

In one of the earliest studies of this type, Ferster (1958) arranged for chimpanzees' responses on one key to produce food according to a variable-interval (VI) 3-min schedule, and responses on a second key to postpone 3-min timeouts from the food schedule. The response–timeout interval, the period of time between a response and the onset of a timeout, was varied across conditions from 1 to 10 min. In the absence of avoidance responding, a timeout occurred every 45 s. Ferster found that postponement responding was acquired and maintained on this procedure, and that rates of responding varied inversely with the length of the response–timeout interval. These results are similar to those obtained on shock-postponement procedures (Sidman, 1953), lending support to the notion that timeouts are functionally similar to other aversive events.

On postponement procedures, however, a response both postpones individual aversive events and reduces the overall frequency of those events, making it difficult to isolate the controlling variables. This confounding effect of short-term postponement and overall frequency reduction is especially problematic in timeout-avoidance studies because changes in timeout frequency produce concomitant changes in the frequency of positive reinforcement available during time-in periods. In Ferster's (1958) experiment, for example, postponing timeouts increased the period of time the VI schedule operated, thereby increasing the overall rate of food delivery. These dual consequences pose a conceptual dilemma; timeout avoidance can be interpreted in terms of either negative reinforcement (postponing timeout) or positive reinforcement (increasing time-in access) (Leitenberg, 1965). To the extent that all prior studies in this domain have utilized some type of free-operant avoidance procedure, this same interpretive problem holds.

The purpose of the present experiments was to examine the effects of timeout postponement on behavior with neither reductions in the overall frequency of timeout nor increases in the overall frequency of positive reinforcement. This was accomplished by using a procedure modeled after Hineline's (1970) discrete-trial shock-avoidance proce-

dure. In that procedure, rats received one shock each trial. Lever presses postponed the shock to a later part of the trial but did not cancel it. Responding thus affected the temporal placement of shock within a trial without changing overall shock frequency. Hineline found that responding was established and maintained on this procedure, demonstrating that shock postponement was sufficient to produce avoidance even without corresponding reductions in overall shock frequency.

The logic of the present study was similar to Hineline's (1970) except that timeouts from a schedule of food reinforcement were substituted for shock. One timeout was scheduled to occur in each trial. A pigeon's key peck in the first 5 s of a trial postponed an otherwise immediate timeout from a random-interval (RI) schedule of food delivery. A response thus determined *when* the timeout occurred but not *whether* it occurred. In this way, it was possible to examine the effects of a timeout-postponement contingency apart from changes in the overall frequency of timeout and of food reinforcement during time in.

The aim of Experiment 1 was to investigate the degree to which responding could be maintained by a timeout-postponement contingency with no changes in overall timeout frequency. Because overall timeout frequency was held constant, the overall amount of time in (and thus the rate of food reinforcement) did not change. The aim of Experiment 2 was to examine timeout-postponement responding as a function of timeout duration. Because trial length was fixed, timeout duration was inversely related to overall rate of food reinforcement: The longer the timeout the lower the rate of food delivery. Thus, this experiment also assessed whether timeout postponement could be maintained when responding decreased the overall rate of food reinforcement. The aim of Experiment 3 was to investigate timeout-postponement responding as a function of the response–timeout interval with no change in timeout frequency or duration. Some conditions of Experiment 3 were arranged to control for variables other than timeout postponement, such as the immediacy of food presentation and food-correlated (time-in) stimuli. By isolating the effects of timeout postponement

from changes in the overall frequency of timeout and food reinforcement, and from local delays to food and food-correlated stimuli, these experiments help to clarify the conditions under which timeout from reinforcement serves as an aversive event.

EXPERIMENT 1

METHOD

Subjects

Four White Carneau pigeons (*Columba livia*), numbered 767, 716, 1398, and 1859, served as subjects. All had previous experimental histories responding on discrete-trial timeout-escape and timeout-deletion procedures, in which responses terminated and canceled programmed timeouts, respectively. Subjects were maintained at approximately 80% of their free-feeding body weights with postsession feedings. Pigeons were individually housed in a colony room where they had continuous access to water and grit. The room was illuminated on a 16.5:7.5 hr light/dark schedule.

Apparatus

One standard Lehigh Valley Electronics operant conditioning chamber for pigeons, measuring 35 cm long, 35 cm high, and 30 cm wide, was used. Two response keys (2.5 cm diameter) were located on the experimental panel 23.75 cm above the grid floor. The center (red) key was 16.5 cm from the right wall and the second (green) key was 8.5 cm from the left. A force of approximately 0.2 N was required to operate the response keys. A houselight, mounted 4.4 cm above the center key, provided diffuse illumination. A centrally located aperture, measuring 5 cm by 5.6 cm and positioned 10 cm above the grid floor, provided access to mixed grain. A ventilation fan helped mask extraneous sound. Experimental events were programmed and data collected with MED-PC® software on an IBM PC-compatible computer located in an adjacent room.

Procedure

A session consisted of 20 125-s trials, each separated by 30-s intertrial intervals (ITIs). During the ITI, the houselight flashed according to a 1-s on-off cycle. Each trial consisted of the following three components: (a) a 5-s response period during which the houselight was illuminated and the center (red) key flashed (1-s on-off cycle), (b) a 60-s time-in period, during which the houselight was illuminated and an RI schedule of food delivery was in effect for pecks on the left (green) key, and (c) a 60-s timeout, during which the houselight and all keylights were dark and responding had no programmed consequences. The RI schedule made food available every 20 s on average, accomplished by sampling a probability gate once per second with a .05 probability. Reinforcement consisted of 3-s access to mixed grain. The 60 s of time in per trial excluded the time for reinforcement. Food deliveries set up by the RI schedule but not collected before the onset of the timeout or ITI were canceled. Sessions were conducted at approximately the same hour 6 days per week.

The trial structure for each condition is diagrammed in Figure 1. A postponement response could occur only during the first 5 s of a trial. (The opportunity to postpone timeouts was restricted to the first 5 s of each trial because previous attempts to establish responding failed when both the postponement and food-schedule contingencies operated concurrently.) In the timeout-postponement condition, a single peck on the red (postponement) key during the first 5 s of a trial extinguished the keylight and, at the end of the 5-s interval, produced the green (food) key for 45 s, followed by a 60-s timeout. The response–timeout interval was thus 45 s. If a center-key response occurred during the final 2 s of the 5-s response period, or if additional responses occurred on the center key when it was dark, the onset of the food key was delayed by an additional 2 s to prevent adventitious pairing of responses and the onset of the food-correlated stimulus. As a result, trials occasionally exceeded 125 s. This occurred on approximately 12% of trials comprising the final 10 sessions of postponement conditions. Following the 60-s timeout, the food schedule was reinstated for 15 s. If no response occurred on the center (postponement) key during the first 5 s of a trial, a 60-s timeout occurred immediately. The no-response–timeout interval was thus 0 s. Following the timeout, the RI schedule was in effect on the left (food) key for the remaining 60 s of the trial.
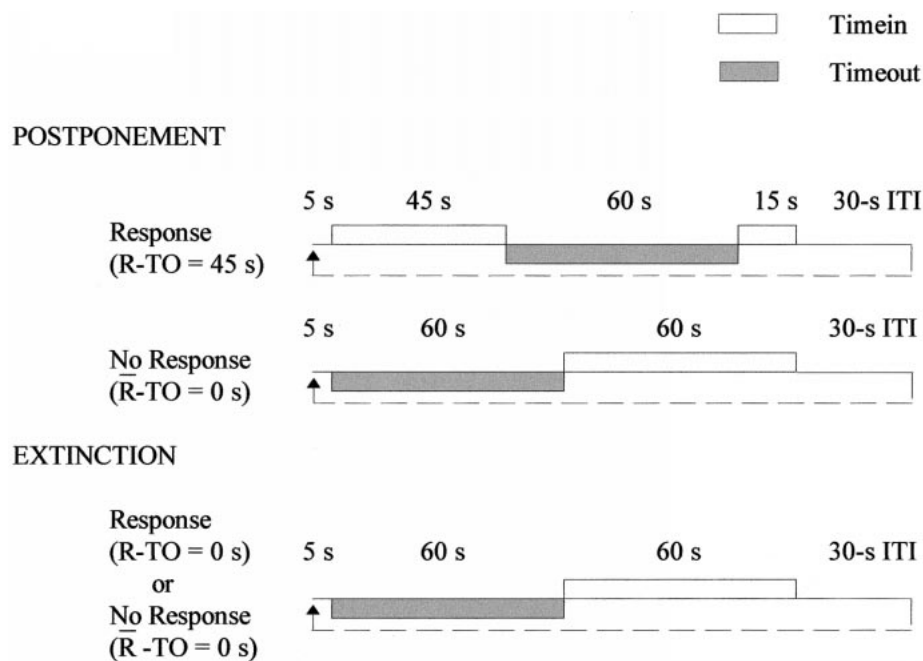
Fig. 1.   Trial structure for postponement and extinction conditions given a response or no response in Experiment 1. The first 5-s interval denotes the period during which a postponement response could occur, filled blocks denote timeouts, and open blocks denote time-in periods. An RI 20-s schedule of food reinforcement operated during time-in periods. Condition labels show the delay to timeout onset given a response or no response.

Under extinction conditions (Figure 1), a timeout occurred at the end of the initial 5-s period irrespective of responding during that period. During conditions designated Extinction 1, a response during this period extinguished the keylight (as in the postponement conditions) but did not postpone the timeout. As before, a response during the final 2 s of the 5-s period postponed the transition by an additional 2 s. If no response occurred, the 5-s interval was followed immediately by

the 60-s timeout. Following the timeout, the RI schedule was reinstated on the food key for the remaining 60 s of the trial. Two subjects (716 and 1398) were exposed to a second extinction procedure (designated Extinction 2) that was identical to the first except that responses during the first 5 s of a trial did not extinguish the keylight. Table 1 shows the sequence and number of sessions for each condition.

An ABAB reversal design was used, with postponement conditions constituting the A phase and extinction constituting the B phase. The primary dependent measure consisted of the percentage of trials per session with a postponement response. Conditions lasted for a minimum of 20 sessions, and until the mean number of trials with a postponement response for the first and last five sessions of a 10-session block did not differ from each other by more than 10% (postponement conditions) or by more than one response (Extinction 1 conditions). Because the Extinction 2 procedure was used merely to provide remedial training for unstable patterns of responding in Extinction 1 condi-

Table 1

Sequence and number of sessions per condition (in parentheses) for each subject in Experiment 1.

Condition	Subject			
	1859	767	716	1398
Postponement	1 (21)	1 (25)	1 (20)	1 (26)
	3 (20)	3 (62)	5 (31)	5 (20)
Extinction 1	2 (49)	2 (29)	2 (50)	2 (90)
	4 (95)	4 (68)	4 (34)	4 (28)
			6 (80)	6 (70)
				8 (37)
Extinction 2			3 (29)	3 (23)
			7 (32)	

tions, formal stability criteria were suspended. Extinction 2 conditions were in effect until visual inspection revealed that the number of trials with a postponement response was consistently low across a five-session block. Following Extinction 2, Extinction 1 conditions were reinstated.

Results

Figure 2 shows the percentage of trials with a postponement response per session across all conditions. Because subjects had previous experience responding on timeout-escape and timeout-deletion procedures immediately prior to the first timeout-postponement condition, responding was rapidly established. Responding was well maintained under all conditions in which the postponement contingency was in effect, with subjects postponing timeouts at a consistently high level. The mean percentage of trials with a response over the final 10 sessions ranged, across subjects, from 91% to 96% and 86% to 98% on the first and second exposures, respectively. For Subjects 1859 and 1398, responding was quickly reestablished during the second exposure, reaching terminal values in as few as two sessions. For Subject 767, the percentage of trials with a response remained near zero for approximately 10 sessions before increasing abruptly, whereas for Subject 716, the percentage of trials with a response increased gradually across sessions.

Timeout postponement decreased markedly for all subjects during extinction conditions. In the first exposure to extinction conditions, the mean percentage of trials with a response eventually dropped to less than 10% for all subjects, although the time course of extinction varied across subjects. For Subjects 1859 and 767, responding required 49 and 29 sessions, respectively, to meet the extinction criteria. For Subjects 716 and 1398, responding also decreased, but was characterized by greater session-to-session variability. These 2 subjects were exposed to the Extinction 2 condition, in which a response neither terminated the keylight nor postponed the timeout. Responding decreased under these conditions for both subjects, and remained at low levels upon reexposure to the Extinction 1 procedure.

Similar effects were observed during the second exposure to extinction conditions.

The mean percentage of trials with a response decreased across sessions, although for Subjects 1859 and 767 responding took longer to extinguish than during the first exposure (extinction criteria met after 95 and 68 sessions, respectively). Subject 1398 was the only subject that required exposure to Extinction 2 conditions. As before, this manipulation successfully decreased responding, which remained low upon the subsequent reexposure to the Extinction 1 procedure. Across subjects, in this second exposure to extinction conditions, the mean percentage of trials with a response during the final 10 sessions ranged from 3% to 11%.

Figure 3 presents the mean number of food deliveries per trial and the mean response rates on the food key for each subject across the final 10 sessions of the two postponement conditions and the final 10 sessions of two Extinction 1 conditions in which the stability criteria were met. Because there was little variability in these measures across replications, results from both exposures to postponement and Extinction 1 conditions have been combined. The number of food deliveries per trial remained near three (the programmed value) across all postponement and extinction conditions. Similarly, response rates on the food key, although differing somewhat across subjects, did not vary systematically with the postponement and extinction conditions. Few responses occurred during timeouts.

Discussion

The high percentage of trials with a response during postponement conditions, and the subsequent decrease in responding during extinction conditions, indicate that a timeout-postponement contingency can effectively maintain responding in a discrete-trial procedure. These results are consistent with findings from prior free-operant (Sidman) timeout-avoidance studies cited earlier, thereby extending the range of circumstances over which a timeout-postponement contingency has been shown to support responding.

In all previous timeout-avoidance studies, timeout postponement was confounded with changes in the frequency of positive reinforcement, making interpretations of avoidance ambiguous. The present experiment separated these two variables, and is thus the
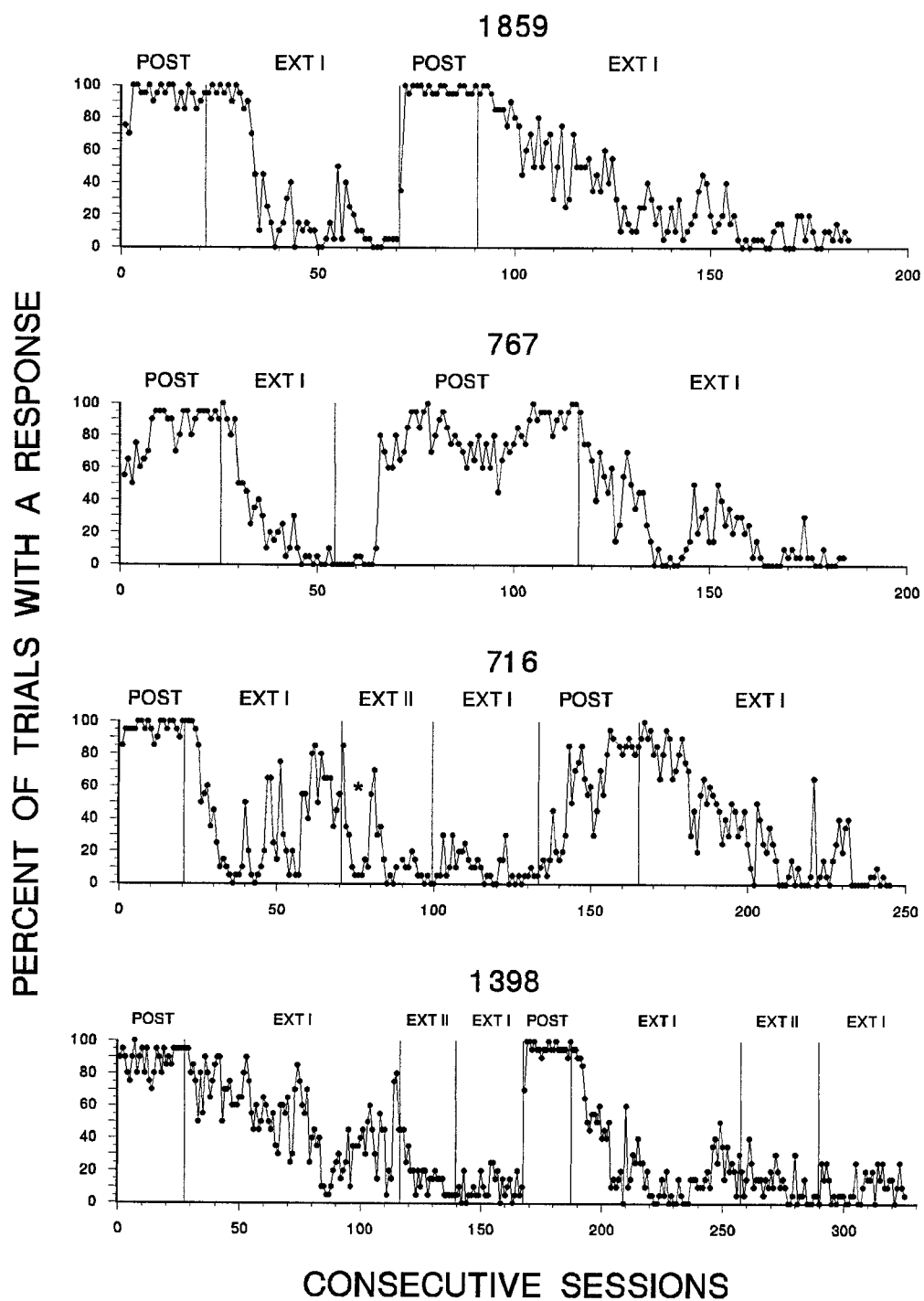
Fig. 2. Percentage of trials with a response per session across postponement (POST) and extinction (EXT) conditions for each subject in Experiment 1. The asterisk represents a session inadvertently conducted on the Extinction 1 procedure.
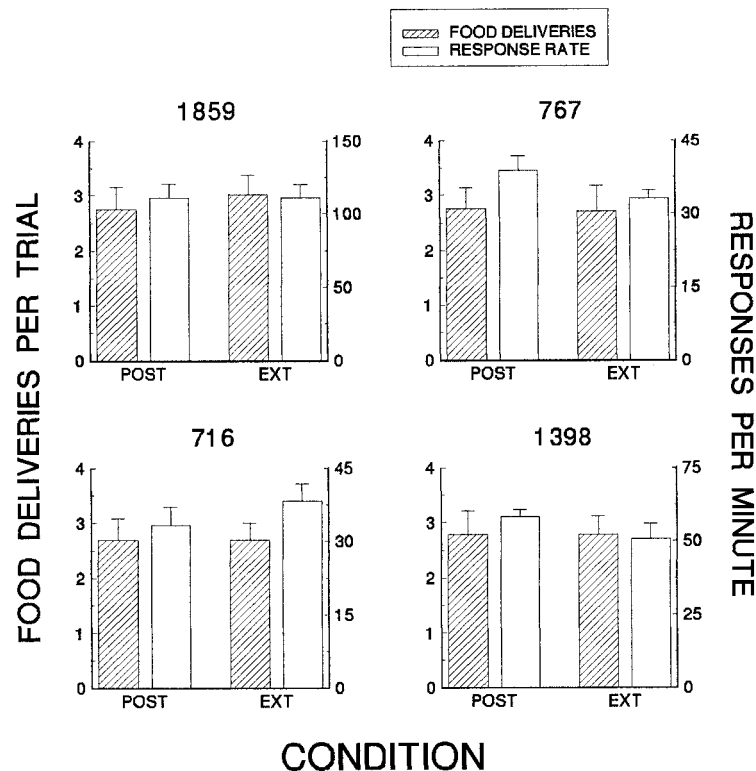
Fig. 3. Mean number of food deliveries per trial (filled bars) and mean responses per minute (open bars) during the RI 20-s (time-in) schedule across the final 10 sessions of postponement (POST) and extinction (EXT) conditions in Experiment 1. Vertical lines show standard deviations. Data from the original exposure and replication have been combined. Note that the right ordinates are scaled individually for each subject.

first to show that a timeout-postponement contingency can maintain responding without increases in the overall frequency of positive reinforcement.

EXPERIMENT 2

The next experiment assessed the generality of this effect by examining the degree to which responding would be maintained by a contingency in which timeout postponement came at the expense of overall rate of food delivery. As in Experiment 1, one timeout was scheduled to occur each trial. In the absence of a postponement response, a 60-s timeout occurred immediately. If a response occurred, the timeout was postponed for 45 s but its duration was increased. The duration of the postponed timeout varied systematically across conditions from 60 s to 105 s. Because trial length was fixed, increasing the timeout duration had the additional effect of

reducing access to the RI schedule, thereby decreasing the overall frequency of food reinforcement. At the longest timeout durations, consistent postponement responding could reduce the frequency of food reinforcement by approximately 50%.

METHOD

Subjects and Apparatus

The subjects and apparatus were the same as those used in Experiment 1, with the exception of Subject 716, which died shortly after the start of Experiment 2. This subject was replaced by Subject 6481, a female White Carneau pigeon, which also had previous experience on timeout-escape and timeout-deletion procedures.

Procedure

A session consisted of 15 trials, each lasting 155 s and separated by 30-s ITIs during which the houselight flashed (1-s on-off cycle). As
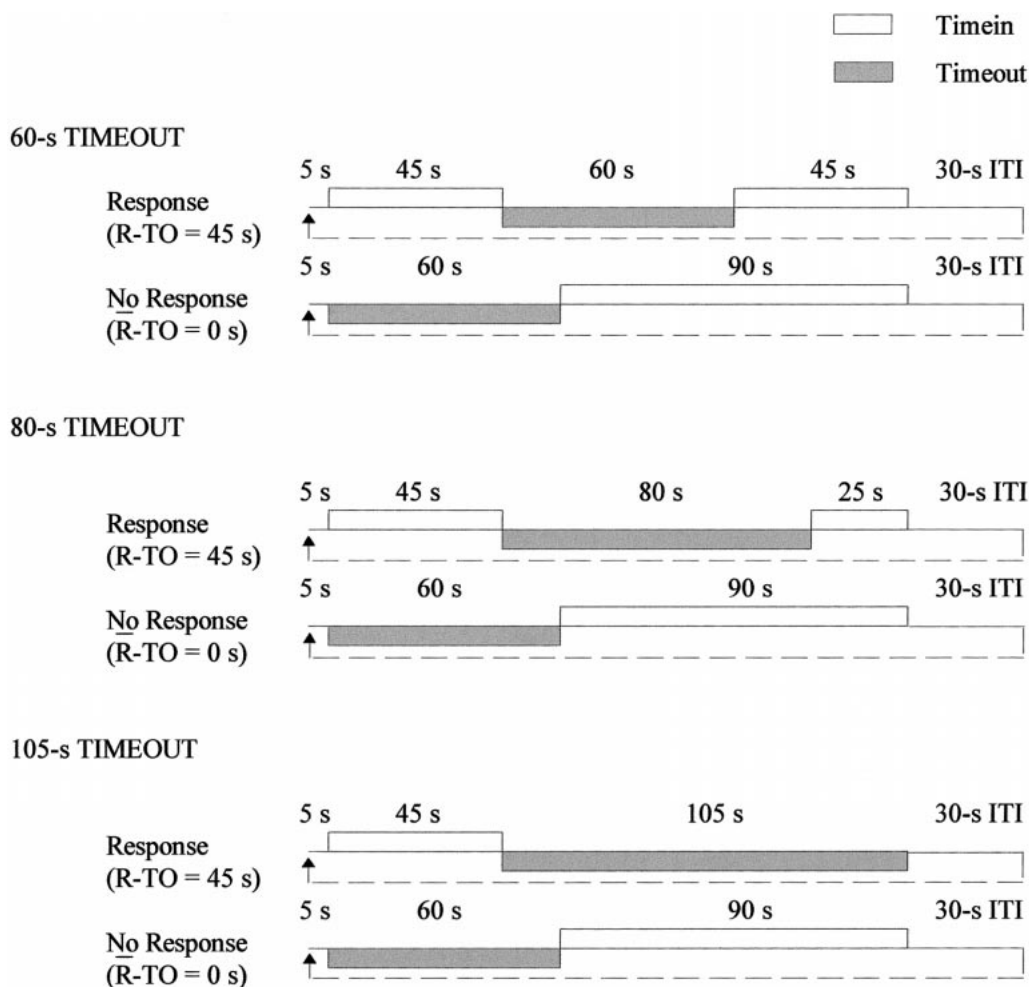
Fig. 4. Trial structure for representative conditions of Experiment 2. The trial sequence is diagrammed for the 60-s, 80-s, and 105-s timeout conditions given a response or no response. All other details are the same as in Figure 1.

in Experiment 1, trials consisted of (a) a 5-s response period, during which the houselight was lit and the center (postponement) key flashed according to a 1-s on-off cycle; (b) a time-in period, during which a RI 20-s schedule of food delivery was in effect for key pecks on the left (food) key; and (c) a timeout, during which the houselight and keylights were extinguished. The general trial structure was as follows: A single peck on the postponement key during the first 5 s extinguished the keylight on that key and, at the end of the 5-s period (and at least 2 s from the last response), illuminated the food key and put into effect the RI schedule for 45 s. A timeout then occurred, after which the RI 20-s schedule was reinstated for the remainder of the

trial. In the absence of a response in the first 5 s of the trial, a 60-s timeout occurred immediately. Following the timeout, the RI schedule was reinstated for 90 s. Food deliveries set up but not collected before the onset of a timeout or ITI were canceled.

The primary manipulation was the duration of the postponed timeout, which varied systematically across conditions from 60 s to 105 s. The trial structure for three of the six conditions is illustrated in Figure 4. Across all conditions, the duration of the immediate timeout given no response was 60 s. Experimental sessions were conducted at approximately the same hour, 7 days per week. Table 2 shows the sequence of conditions and the number of sessions conducted at each. Two
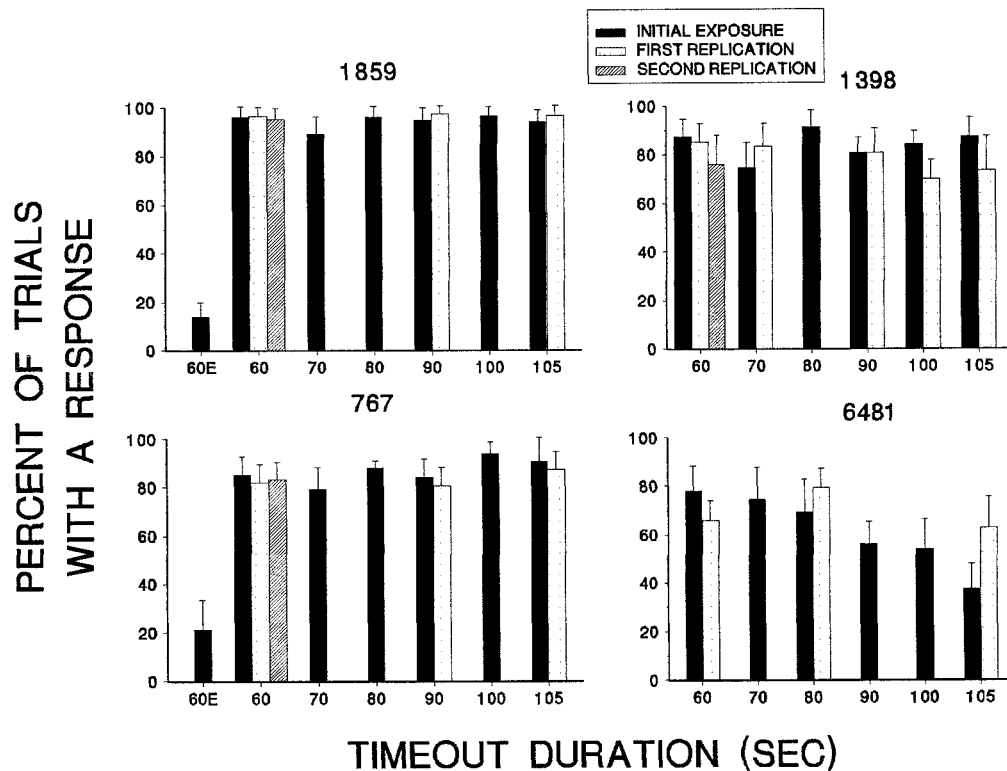
Fig. 5. Mean percentage of trials with a postponement response as a function of timeout duration across the final 10 sessions of each condition for each subject in Experiment 2. Solid bars indicate initial exposures, open and filled bars are replications, and vertical lines show standard deviations.

Table 2

Sequence and number of sessions per condition (in parentheses) for each subject in Experiment 2. E denotes an extinction condition.

Time-out dura-tion (s)	Subject			
	1859	767	1398	6481
60	1 (43)	1 (48)	1 (27)	1 (39)
	7 (32)	7 (39)	9 (21)	5 (41)
	10 (75)	10 (23)	11 (84)	
70	2 (21)	2 (24)	2 (63)	7 (26)
			7 (44)	
80	3 (34)	3 (20)	4 (32)	3 (44)
				9 (33)
90	4 (20)	4 (20)	6 (55)	6 (42)
	8 (21)	9 (67)	12 (20)	
100	5 (20)	5 (32)	3 (103)	4 (28)
			8 (75)	
105	6 (21)	6 (38)	5 (58)	2 (138)
	9 (20)	8 (68)	10 (52)	8 (71)
60E	11 (52)	11 (56)		

subjects (1859 and 767) were first exposed to an ascending sequence of timeout durations, and the other 2 subjects (1398 and 6481) were exposed to a varied sequence. Replications occurred in a varied order for all subjects. For 2 subjects that showed little sensitivity to timeout duration (Subjects 1859 and 767), the final condition was an extinction condition in which responses during the first 5-s period extinguished the keylight but did not postpone timeouts (similar to Extinction 1 conditions of Experiment 1). Stability criteria were identical to those used in Experiment 1.

RESULTS

Figure 5 shows for each subject the mean percentage of trials with a response over the final 10 sessions of each condition. Under baseline conditions, with 60-s timeouts, the percentage of trials with a postponement response was consistently high for all 4 subjects. For Subjects 1859, 767, and 1398, increasing
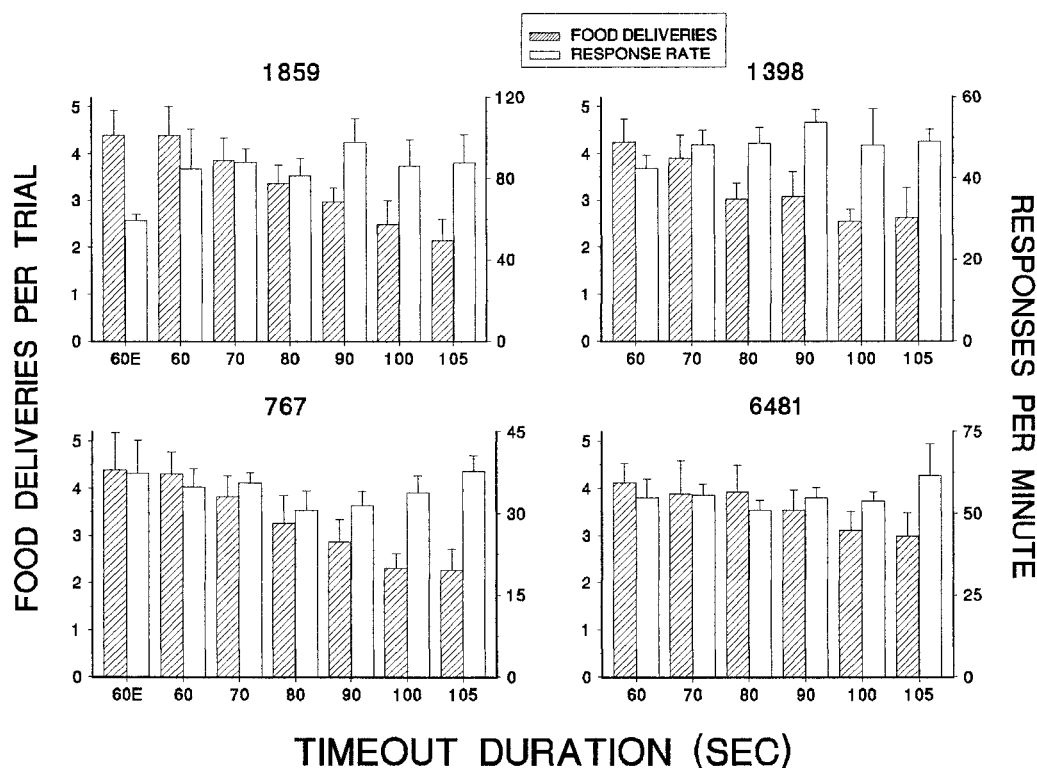
Fig. 6.   Mean number of food deliveries per trial (filled bars) and mean responses per minute (open bars) as a function of timeout duration across the final 10 sessions of each condition for each subject in Experiment 2. Results from the original exposures and replicated conditions have been combined. Vertical lines show standard deviations. Note that the right ordinates are scaled individually for each subject.

the timeout duration beyond 60 s had little effect on postponement responding; responding was maintained across all timeout durations. Responding was somewhat more sensitive to timeout duration in Subject 6481. The percentage of trials with a response decreased systematically with timeout duration on the first exposure to each timeout duration, but was less affected by timeout duration on the second exposure. For the 2 subjects exposed to extinction conditions (1859 and 767), responding decreased to low levels when the postponement contingency was removed (Condition 60E, Figure 5).

Figure 6 shows the mean number of food deliveries per trial and the response rate on the food key across all experimental conditions for each subject. Because there was little variability in these measures across replications, data from the original exposures and replications have been combined. Postponement responding under conditions with lon-

ger timeouts produced corresponding reductions in the frequency of food reinforcement. In the absence of postponement responding, the mean number of food deliveries per trial in all conditions would be comparable to that of the 60-s timeout duration (and extinction) conditions. Instead, the number of food deliveries per trial decreased across conditions, dropping to nearly half the value of the baseline condition at the longest timeout duration. The smallest reduction in the mean number of food deliveries per trial occurred with Subject 6481, as this subject emitted fewer postponement responses across conditions than the other subjects and thus spent less time per trial in timeout. As in the first experiment, response rates on the RI key remained fairly constant across conditions, and few responses occurred during timeout.

DISCUSSION

Responding was maintained across all postponement conditions, even when such re-

sponding increased timeout duration and decreased the frequency of food reinforcement by as much as 50%. For only 1 subject was responding sensitive to timeout duration, but even for this subject responding occurred on over half of the trials in eight of nine experimental conditions. That the 3 subjects showing the least sensitivity to timeout duration also participated in Experiment 1 raises the possibility that an extensive history with the postponement contingency influenced responding. Partly for this reason, 2 of these subjects were exposed to extinction conditions. Responding decreased to low levels during extinction conditions, indicating that previous experience alone could not account for the maintenance of postponement responding.

In general, these findings are consistent with and extend the results of Experiment 1. Whereas the first experiment showed that decreases in overall timeout frequency and increases in reinforcement frequency were not necessary for timeout postponement, the present experiment demonstrated that postponement persisted in the face of sometimes large increases in timeout duration and concomitant decreases in the frequency of food reinforcement.

When viewed in light of the marked reductions in the overall frequency of food reinforcement, responding in this experiment may be regarded as suboptimal. It is important to recognize, however, that a response, in addition to postponing the timeout, also reinstated time-in conditions for 45 s. Perhaps the reductions in overall food rate were simply too remote to override the immediate 45 s of food and food-related (time-in) stimuli. In Experiment 3, we examined the effects on postponement responding of shorter response–timeout intervals while holding timeout duration constant at 60 s.

We also controlled for differences in local delays to food and food-correlated stimuli following a response versus no response. Because time-in conditions were restored more immediately if a response occurred, local response–reinforcer and stimulus–reinforcer contingencies may have influenced responding apart from the timeout-postponement contingency. Transition to the food-correlated stimulus signaled a reduction in delay to food, and might therefore be expected to serve both as a more effective conditioned reinforcer and a more effective conditioned stimulus than transition to the blackout that prevailed in the absence of a response. It is unclear what role such local response–food and stimulus–food relations may have played in the maintenance of responding. Several additional conditions in Experiment 3 were designed to control for such differential local relations. Timeouts still occurred relatively later in the trial following a response, but the no-response–timeout interval was greater than 0 s, such that the local time-in conditions were the same whether a response occurred or not. If responding was maintained under these conditions, it would imply strong control by the postponement contingency. Conversely, if responding weakened when differential food-related delays were eliminated, it would suggest that such local variables contributed to responding under the postponement contingency.

EXPERIMENT 3

METHOD

Subjects and Apparatus

Four White Carneau pigeons served as subjects, 3 of which (1859, 1398, and 6481) had participated in Experiment 2. Subject 1398 died after completing four conditions and was replaced by Subject 2102, a male White Carneau pigeon with previous experience responding on a timeout-escape procedure. The apparatus was the same as in Experiments 1 and 2.

Procedure

The trial structure and general procedures follow closely those of Experiment 2. A session consisted of 15 155-s trials separated by 30-s ITIs. Each trial included a 5-s response period, a 60-s timeout, and 90 s of time in. During timeouts, the houselight and keylights were extinguished and key pecks had no programmed consequences. During time in, responses on the left (food) key produced 3-s access to grain according to an RI 20-s schedule. In the 5-s response period the center (postponement) key flashed according to a 1-s on-off cycle. If a center key peck occurred during the 5-s response period, the keylight was extinguished, the timeout was postponed,
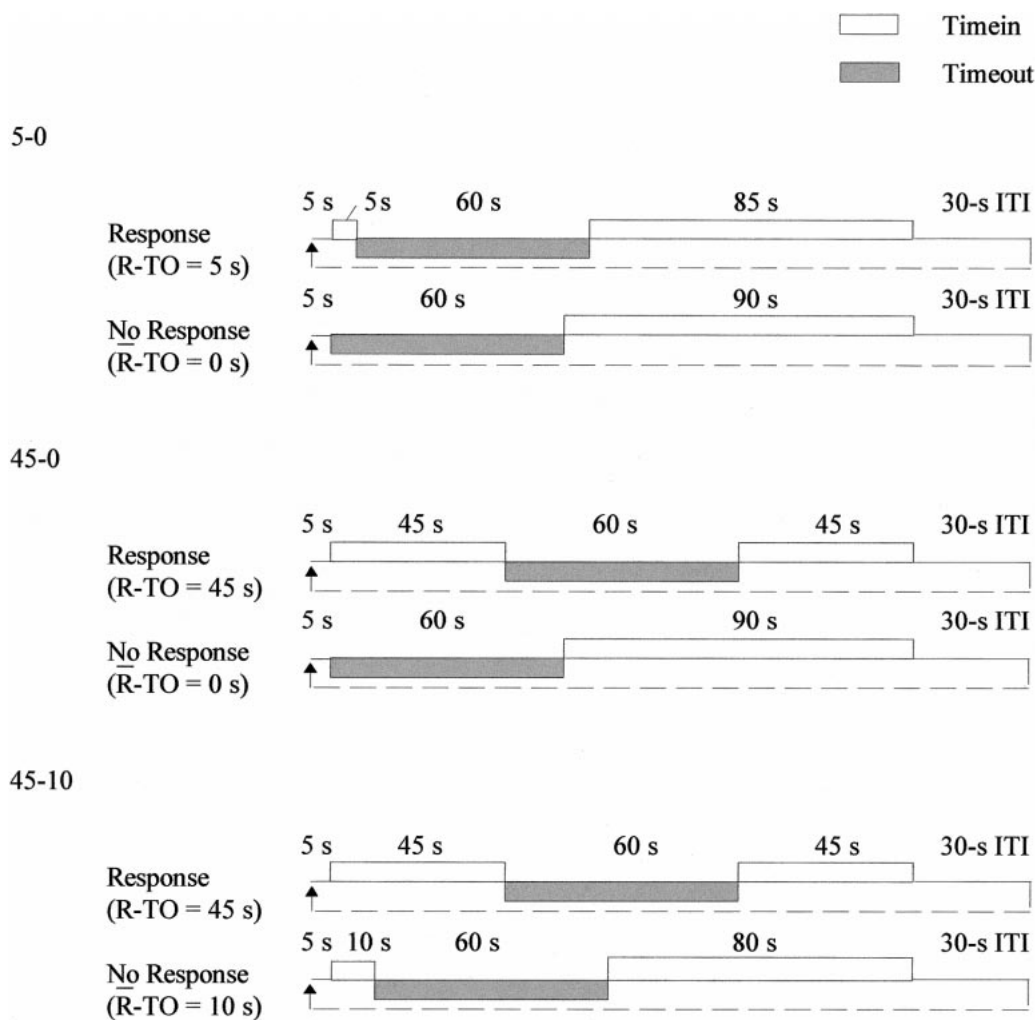
Fig. 7.   Trial structure for representative conditions of Experiment 3. The trial sequence is diagrammed for the 5-0, 45-0, and 45-10 conditions. Condition labels show the delay to timeout onset given a response and no response, respectively. All other details are the same as in Figures 1 and 4.

and, at least 2 s from the last response, the left (time-in) key turned green. Across the first sequence of conditions, the response–timeout interval was systematically varied from 45 s to 0 s (the 0-s condition was identical to the Extinction 1 condition of Experiment 1). In the absence of a postponement response the timeout occurred immediately. In the remaining conditions, the response–timeout interval was held constant at 45 s while the no-response–timeout interval was either 10 s (1 subject) or 10 s and 3 s (2 subjects). Thus, in these two conditions the green (time-in) key was reinstated immediate-

ly following the 5-s response period regardless of whether a postponement response occurred.

The trial structure of three conditions (5-0, 45-0, and 45-10) is shown in Figure 7. Each condition label indicates the response–timeout and no-response–timeout intervals, respectively. As in Experiment 1, timeout postponement did not affect programmed timeout frequency (one per trial) or the overall amount of time in (90 s per trial).

Table 3 shows the condition sequence and number of sessions per condition for each subject. Subjects 1859 and 6481 were exposed

Table 3

Sequence and number of sessions per condition (in parentheses) for each subject in Experiment 3. The condition labels indicate the timeout onset (in seconds) following a response or no response, respectively.

Condition	Subject			
	1859	1398	6481	2102
0-0	9 (60)		6 (23)	2 (20)
				4 (20)[a]
5-0	4 (22)	3 (35)	3 (94)	
	6 (68)		5 (104)	
	8 (102)			
15-0	3 (20)			
25-0		2 (21)	2 (71)	
35-0	2 (20)			
45-0	1 (68)	1 (57)	1 (51)	1 (72)
	5 (20)	4 (24)	4 (122)	
	7 (20)		7 (127)[a]	
	13 (55)		12 (41)[a]	
45-3			9 (40)[a]	6 (41)[a]
			10 (20)[a]	
			11 (29)[a]	
45-10	10 (22)		8 (29)[a]	3 (44)
				5 (49)[a]
				7 (37)[a]
Keylight on	11 (61)			
Keylight on, houselight flash	12 (26)			

[a] Procedure modified. See text for details.

to both sequences of conditions. Subject 1398 received exposure only to the first, whereas Subject 2102 received exposure only to the second. Response–timeout intervals were presented in a descending order and replications occurred in a varied order. For Subject 6481, the food-access time was reduced from 3 s to 2 s during the second exposure to the 45-0 condition and remained at that value across all subsequent experimental conditions. Experimental sessions were conducted at approximately the same hour, 7 days per week, and the stability criteria were identical to those used in the first two experiments.

To determine the effects on timeout postponement of the offset of the pretimeout stimulus, two additional conditions were conducted with Subject 1859. In one, called the keylight-on condition, a response in the presence of the flashing center keylight in the first 5 s of the trial postponed an immediate timeout by 45 s but did not extinguish the keylight. This was followed by a condition called keylight on/houselight flash, which was identical to the keylight-on condition except that responses produced a brief (0.2-s)

flash of the houselight while the center key remained on. This was followed by a return to the baseline (45-0) condition, in which a response both postponed the timeout and extinguished the center keylight. Approximately 21 months intervened between these last two conditions and the conditions for Experiment 3 proper. During this time Subject 1859 received exposure to several timeout-postponement procedures similar to baseline (45-0) conditions except that the stimulus conditions accompanying timeout were varied. These data are not presented here.

Several procedural modifications were made for Subjects 6481 and 2102 during the experiment. First, because observations revealed that responses rarely occurred during the 1-s off cycle of the flashing center keylight during the 5-s postponement response period, the rate at which this stimulus flashed was changed from 1 s on-off to 0.2 s on-off. Second, to prevent postponement responses from delaying the onset of the green (time-in) stimulus during the 45-10 and 45-3 conditions, the 2-s delay programmed between a postponement response and onset of time in was removed. Third, for Subject 6481 during the first replication of the 45-3 condition, postponement responses, rather than extinguishing the center keylight, produced a brief (0.2-s) houselight flash. In the second replication of the 45-3 condition, key pecks during the first 3 s of time in had no programmed consequence (extinction). Fourth, in the early stages of conditions immediately following those in which few postponement responses occurred (e.g., extinction), five forced-response trials were presented prior to the 15 standard trials to bring responding into contact with the postponement contingency. On forced-response trials the normally 5-s postponement period remained in effect until a center key peck occurred. These forced-choice trials were removed once sufficient exposure to the contingencies had been established and, with the exception of the two replications of the 45-3 condition for Subject 6481, before the terminal 10 sessions of the condition.

RESULTS

Figure 8 shows the mean percentage of trials with a postponement response across the final 10 sessions of each condition for all sub-
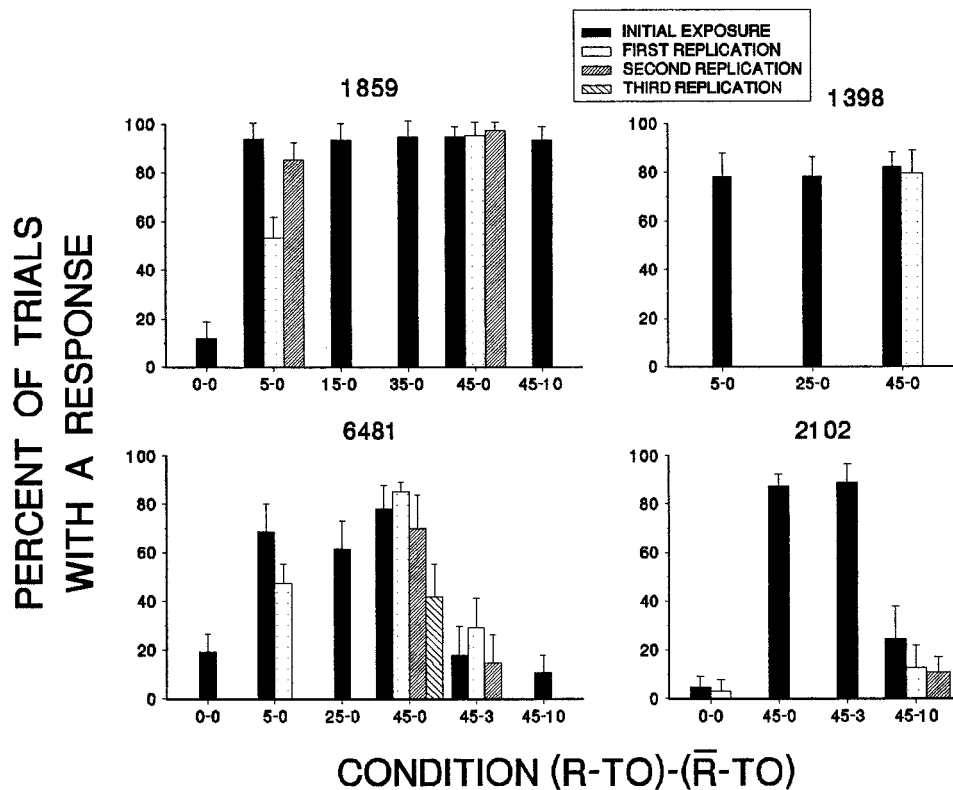
Fig. 8.   Mean percentage of trials with a response across the last 10 sessions of each condition. Solid bars indicate initial exposures, open and filled bars are replications, and vertical lines show standard deviations. The condition labels show the delay to timeout onset given a response and no response, respectively.

jects. With one exception (the final 45-0 condition for Subject 6481), responding occurred at consistently high levels across all conditions in which it postponed an otherwise immediate timeout. For Subject 6481, the percentage of trials with a postponement response decreased somewhat at some of the shorter response–timeout intervals, but in all but one condition (second exposure to response–timeout = 5 s) responses occurred on at least half of the trials. For all subjects, postponement responding decreased to low levels under 0-0 (extinction) conditions, indicating that responding was sensitive to the postponement contingency.

In the second sequence of conditions, in which the no-response–timeout interval was either 10 s or 3 s (45-10 and 45-3), the pattern of responding varied across subjects. For Subject 1859, there was little disruption in responding: A postponement response occurred on 93% of the trials in the 45-10

condition. For Subject 2102, postponement responding was well maintained under the 45-3 condition (89% of trials with a response) but decreased to low levels under the 45-10 condition. For Subject 6481, responding was not well maintained under either condition. As noted above, a return to baseline conditions (45-0) following the 45-3 and 45-10 conditions did not bring responding back to its previously high levels. For neither Subject 6481 nor 2102 did responding appear to be affected by the modified stimulus conditions (rate of flashing keylight) that prevailed during the postponement period.

Figure 9 shows the mean number of food deliveries per trial and the mean response rate on the food key of the last 10 sessions of each condition. Data from the original exposures and replications have been combined. For each subject, the mean number of food deliveries per trial remained near the programmed value of 4.5 across all condi-
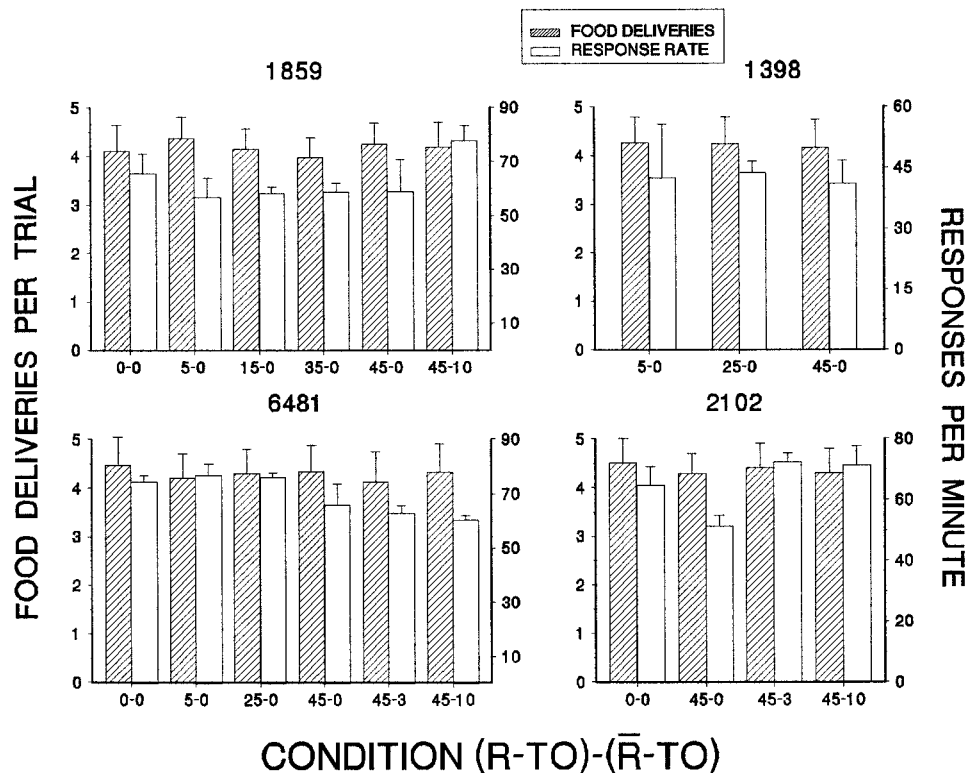
Fig. 9. Mean number of food deliveries per trial (filled bars) and mean responses per minute (open bars) across the last 10 sessions of each condition for each subject. Results from original exposures and replicated conditions have been combined. Vertical lines show standard deviations. The condition labels show the delay to timeout onset given a response and no response, respectively. Note that the right ordinates are scaled individually for each subject.

tions. Response rates did not vary systematically with the timeout-delay value and few responses occurred during timeout.

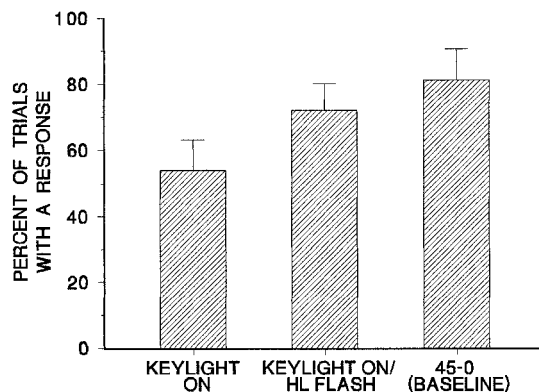Figure 10 shows the mean percentage of

Fig. 10. Mean percentage of trials with a postponement response across the final 10 sessions of the keylight-on, houselight-flash, and 45-0 (baseline) conditions for Subject 1859. The vertical lines are standard deviations.

trials with a response during the final 10 sessions of the control conditions conducted with Subject 1859. The percentage of trials with a postponement response was lowest in the keylight-on condition, with postponement responses occurring on approximately half of the trials. When timeout-postponement responses produced a brief houselight flash, the percentage of trials with a response increased to values more similar to those observed during the final 45-0 (baseline) condition.

DISCUSSION

Responding was maintained consistently in conditions in which it postponed an immediate timeout. These results extend those of the first two experiments in showing that a timeout-postponement contingency can support responding across a range of response–timeout values without changes in the overall frequency of timeout or food reinforcement.

A potential confounding effect in Experiments 1 and 2 and in the initial conditions of Experiment 3 was the differential food and food-correlated delays following a response. That is, time-in conditions were reinstated more immediately following a response than following no response, raising the possibility that local food-related variables exerted control over responding. The 45-3 and 45-10 conditions of Experiment 3 were designed to hold constant these local time-in variables, permitting a clearer examination of the timeout-postponement contingency. The pattern of responding was somewhat mixed for the 3 subjects exposed to these conditions. For Subject 1859, eliminating differential time-in delays following a response had little effect on responding, suggesting strong control by the postponement contingency. For Subject 2102, behavior was sensitive to the no-response–timeout interval: Responding occurred at high levels under 45-3 but not under 45-10 conditions, suggesting limits on the effectiveness of the postponement contingency. The weak control by the postponement contingency under the 45-10 condition suggests that for this subject, local time-in variables contributed to responding. On the other hand, the strong responding under the 45-3 condition indicates that such local control is not limited to contiguous food-correlated stimuli. Together, the responding of Subjects 1859 and 2102 suggest that differential delays to food or food-correlated stimuli may contribute to, but are not solely responsible for, responding controlled by timeout-postponement contingencies.

For a 3rd subject (6481), eliminating the differential local contingencies following a response decreased the level of responding considerably. That responding returned only partially under baseline conditions (45-0), however, complicates interpretation of these results. It is also worth noting that responding for this subject was somewhat more sensitive to variations in both timeout duration (Experiment 2) and response–timeout interval (Experiment 3) than it was for the other subjects, perhaps reflecting generally weaker control by timeout-postponement contingencies.

Another factor that may have contributed to postponement responding was the response-contingent removal of the pretimeout stimulus. This possibility was first suggested by some of the results of the extinction conditions of Experiment 1, in which responding was not completely extinguished for 2 subjects under conditions in which responses terminated the pretimeout stimulus in the first 5 s of the trial. Only when the contingency between a response and keylight offset was removed was responding abolished. Similarly, during the keylight-on condition in this experiment, responding occurred less frequently than under baseline conditions, suggesting perhaps that the response-contingent removal of the pretimeout stimulus negatively reinforced responding. It is also possible, however, that the termination of the keylight served primarily a conditioned reinforcing rather than a conditioned aversive function by producing stimulus conditions that were followed immediately by a food-correlated (time-in) stimulus in a chain-like fashion. The keylight-on/houselight-flash condition was designed to distinguish between these two potential functions. The brief response-contingent stimulus (flashing houselight) preserved the temporal relation between a response and the terminal-link (time-in) stimulus (thereby maintaining the potential for conditioned reinforcement), and the constant stimulus conditions before and after a response eliminated the basis for negative reinforcement by removal of the conditioned aversive (pretimeout) stimulus. That responding under houselight-flash conditions was more similar to that under baseline conditions than under keylight-on conditions is broadly consistent with a conditioned reinforcement interpretation. Because these conditions were conducted with only 1 subject, however, these conclusions must be regarded as tentative.

GENERAL DISCUSSION

Consistent with prior findings, the present results showed that responding can be maintained by postponing timeouts from a schedule of food delivery (D'Andrea, 1971; Ferster, 1958; Galbicka & Branch, 1983; Thomas, 1964, 1965a, 1965b; van Haaren & Zarcone, 1994). In past studies, the effects of timeout-postponement contingencies have been confounded with increases in the frequency of food reinforcement—an inevitable result of

increased access to the reinforcement schedule available during time-in periods. Thus, responding could be viewed either in terms of negative reinforcement (avoiding timeouts) or positive reinforcement (increases in the overall frequency of food delivery). In the present research, responding was maintained with no change (Experiments 1 and 3) and with marked reductions (Experiment 2) in the overall frequency of food delivery, calling into serious question interpretations of timeout avoidance that appeal solely to correlated changes in the frequency of positive reinforcement.

By isolating the effects of timeout delay from changes in timeout frequency, the present results parallel those obtained in the shock-avoidance realm, in which local delays to shock are sufficient to establish and maintain responding in the absence of reductions in overall shock frequency (Gardner & Lewis, 1976, 1977; Hineline, 1970). This suggests that timeouts are perhaps best conceptualized as aversive events analogous to shock. That responding showed generally little sensitivity to changes in timeout duration (Experiment 2) or response–timeout interval (Experiment 3), however, may lead some to question the aversiveness of timeout. It is possible that these variables were either not manipulated across an effective range of values or that the particular value at which one variable was held constant masked sensitivity to the other variable. For example, the effects of timeout duration were examined at a single response–timeout interval of 45 s, and the effects of response–timeout interval were examined at a single timeout duration of 60 s. Perhaps greater sensitivity to these variables would have been seen had timeout duration been manipulated at shorter response–timeout intervals and response–timeout interval been manipulated at longer timeout durations. These are topics for further research.

It is also worth noting that the effects of timeout duration and response–timeout interval were confounded with changes in local time-in conditions. Food and food-correlated (time-in) stimuli were differentially related to responding under most conditions, raising the possibility that behavior apparently under the control of negative reinforcement contingencies was instead under the control of local response–reinforcer or stimulus–reinforcer contingencies. This possibility was addressed and partially ruled out by some conditions in Experiment 3 in which contiguous access to time-in conditions occurred without regard to responding. That responding persisted in the absence of differential delays to food and food-correlated stimuli in 2 of 3 subjects shows that timeout postponement is not merely a by-product of control by local response–reinforcer or stimulus–reinforcer variables. The mixed pattern of responding across subjects, however, suggests that such local variables may have contributed to responding.

At first glance, the finding that postponement responding was influenced by local reinforcement variables may appear to challenge the view that timeouts are aversive. It is important to recognize, however, that for responding to come under control of a timeout-postponement contingency, it must be sensitive to time-in reinforcement variables. Timeouts would otherwise cease to be aversive, for they are defined as such only in relation to the more favorable conditions prevailing during time in. That the aversiveness of timeout depends upon time-in conditions is perhaps best illustrated by findings showing that when the probability of reinforcement during time-in periods is low (e.g., the time immediately following reinforcement on fixed-ratio schedules), responding can be maintained by contingent production of timeout (Azrin, 1961; see also Appel, 1963).

As other authors have noted (e.g., Galbicka & Branch, 1983), timeout avoidance is not alone among negative reinforcement procedures in giving rise to interpretations couched in terms of positive reinforcement. In discriminated shock-avoidance procedures, for example, responses both cancel shock and remove preshock (warning) stimuli. Responding can thus be viewed in terms of negative reinforcement (preventing shock) or positive reinforcement (producing shock-free or "safety" periods) (Dinsmoor, 1977). Furthermore, as Badia, Coker, and Harsh (1973) note, within aversive contexts in general, a positive reinforcement interpretation can be brought to bear whenever safety periods (or periods free of aversive stimuli) are discriminable from periods containing aversive stimuli: Responses that remove aversive stimuli produce safety periods, and responses

that produce aversive stimuli remove safety periods.

Because most, if not all, negative reinforcement procedures are subject to these dual interpretations, acknowledging a role for positive reinforcement in timeout-avoidance studies does not imply that timeouts are not aversive. By the same token, showing effective avoidance responding does not imply indifference to local positive reinforcement variables. Positive reinforcement variables define the reinforcing effectiveness of time-in periods, which, in turn, determine whether transitions from time in to timeout are reinforcing or aversive. This interdependence of time in and timeout means that the precise functions of timeout (reinforcing, aversive, or neutral) will depend on a number of variables involving positive and negative reinforcement contingencies.

In the procedures used in the present research, for example, responding could potentially come under control of one or some combination of several variables—timeout delay, timeout duration, delay to food, delay to food-correlated (time-in) stimuli, and overall rate of food delivery. Rather than attempt to fit these variables all into a single interpretive mold, perhaps it would be more profitable to view timeout-avoidance phenomena in terms of both positive and negative reinforcement operations, emphasizing situational changes that accompany responding, including changes in the distribution of positive and negative reinforcers, changes in the stimuli that signal those events, and the nature of the relation between these situation changes and behavior. The main contribution the present research makes toward this end is the demonstration that across a range of conditions, responding is maintained by delaying the transition from a relatively rich schedule of positive reinforcement to a signaled extinction period without increases (and despite sometimes large decreases) in the overall rate of positive reinforcement.

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